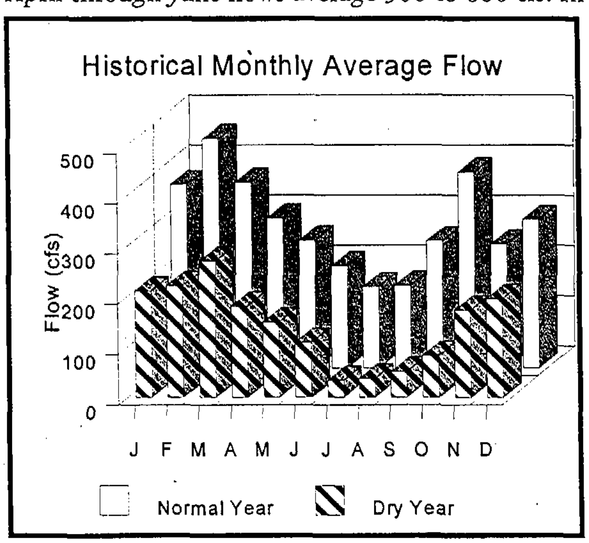
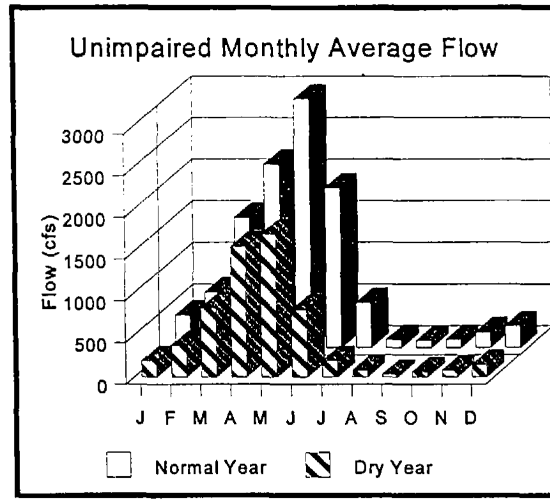
southern half of Yosemite National Park The average unimpaired runoff in the basin is approximately 1.02 million af, similar to the Stanislaus River drainage.

Agricultural development began in the 1850s, and significant changes have been made to the hydrologic (water circulation) system since that time. The enlarged New Exchequer Dam, forming Lake McClure with a gross storage capacity of 1,024,000 af, was constructed in 1967 and now regulates releases to the lower Merced River. The dam is operated by Merced Irrigation District (MID) for power production, irrigation, and flood control. The river is also regulated by McSwain Dam (an afterbay for New Exchequer Dam) and Merced Falls and Crocker-Huffman diversion dams located downstream. Approximately 500,000 af of water is diverted each year at Merced Falls and Crocker-Huffman Dams.

Merced River unimpaired inflows to its watershed are typical of southern Sierra streams with headwaters in the high mountains. Monthly unimpaired flows at Lake McClure average approximately 1,325 cfs, with peak runoff as snowmelt from April through June. Rainfall can cause substantial runoff from December through March. Unimpaired flows in late summer and early fall are generally less than 100 cfs in all but wet years. In highest rainfall years, average monthly inflows range from 6,000 cfs to 12,000 cfs from February through July. In driest years, flows are less than 20 cfs from August through December, whereas April through June flows average 300 to 600 cfs. In dry and normal years, spring inflows average 800 to 1,700 cfs and 2,000 to 3,000 cfs, respectively, whereas August through October flows range from 30 to 100 cfs.



Merced River Streamflow at Stevinson, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)



Unimpaired Merced River Streamflow at Lake McClure, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Monthly historic flow data near the mouth of the Merced River at Stevinson indicate that the water storage and delivery systems are extremely efficient on the Merced River. The historical average flow is approximately 650 cfs (50% of unimpaired), with most of this flow occurring during winter rainfall periods or in fall during reservoir flood control releases. Summer flows are less than 50 cfs in driest years. In highest rainfall years, flows in February through June average 4,000 to 5,500 cfs, whereas flows in August and September average 1,000 to 2,000 cfs. In dry and normal years November to April flows range from 150 to 450 cfs, while July to September flows range from 30 to 200 cfs.

In addition to streamflow, available natural spawning habitat also limits salmon production in the Merced River. Physical habitat for salmon spawning and rearing has been lost or degraded because of channel changes caused by many years of low-flow releases. These changes include siltation of spawning gravel; lack of spawning gravel recruitment below the reservoirs; removal of bankside riparian vegetation, reducing stream shading and bank stability; and in-channel mining, which has removed spawning gravel, altered the migration corridor, and created excellent salmon predator habitat.

Spawning and rearing habitat in the Merced River is the most degraded among the San Joaquin basin tributaries. Legally required summer flow releases are low (15 to 25 cfs) and are usually depleted before they reach the river mouth because of small water diversions throughout the lower river. In portions of the spawning reach and below, riparian (waterside) vegetation has been removed for agricultural development, cattle grazing, urban development, and gravel mining.

Gold dredging in the early 1900s removed significant quantities of spawning gravel from the Merced River. Large tailing piles remain along the spawning reach, and there is a lack of recruitment of new spawning gravel due to the dams, gravel mining, bank protection, and levee construction. In many riffles, significant armoring has also occurred, with only large cobbles remaining. In-channel gravel mining was extensive along the Merced River. Downstream from the State Route 59 bridge, the river flows through large mined-out pits in the channel. Some pit areas have been isolated from the active channel by levees; however, most of these levees were poorly designed and have been breached during flood flows. The ponds and small lakes resulting from these pits create excellent salmon predator habitat, disrupt salmon migration, trap juvenile salmon when water recedes, and raise stream temperatures.

Juvenile salmon are lost in water diverted at the six medium-sized irrigation diversions in the salmon spawning portion of the Merced River. The Davis-Grunsky contract between the California Department of Water Resources (DWR) and MID requires the district to install and maintain fish screening devices at these diversions. Rock screens, consisting of perforated conduit buried in cobble-filled gabions, have been installed at four of the diversions. These structures are only moderately effective at preventing juvenile salmon loss in diverted water. The screens quickly become clogged with vegetation, and the bypass gates, which allow diversion without water passing through the screens, are often opened when the screens become clogged.

DFG surveys on the lower Merced River have identified 68 small pump irrigation diversions; none is adequately screened to prevent entrainment of juvenile salmon. Cumulative losses at these sites are unknown.

Flow releases are not sufficient to accommodate salmon migration, spawning, egg incubation, juvenile rearing, and smolt emigration on the Merced River. Flows in the spawning reach during the spawning and early rearing period are further depleted by water diversions. Spring flows for smolt emigration are particularly inadequate.

Streamflow for fishery purposes in the lower Merced River is mandated in FERC License No. 2179 for the New Exchequer Project, issued in April 1964, and Davis-Grunsky Contract No. D-GG417 (DWR Contract No. 160282) between DWR and MID, executed in October 1967. The Davis-Grunsky contract requires MID to maintain a continuous flow of between 180 cfs and 220 cfs from November 1 through April 1 throughout the reach from Crocker-Huffman Dam to Shaffer Bridge.

Adequate releases for upstream attraction of adults and spawning begin on November 1, but upstream migration typically begins in October. The present spawning and rearing flow requirements were not established by scientific studies and are too low to meet spawning and rearing needs. In addition, six major riparian diversions in the spawning reach from Crocker-Huffman Dam to below Snelling deplete these flows. At times, significant portions of the spawning reach receive flows less than the legally required amounts. Required streamflows are measured at the Shaffer Bridge gage, which is downstream from several irrigation returns.

The most significant deficiencies in the present flow requirements for chinook salmon occur in the spring emigration period. April and May flows required in the FERC license are 75 cfs in a normal year and 60 cfs in a dry year. Smolt survival studies conducted in the other tributary streams in the San Joaquin drainage indicate that significantly higher spring flows are needed in the lower Merced River.

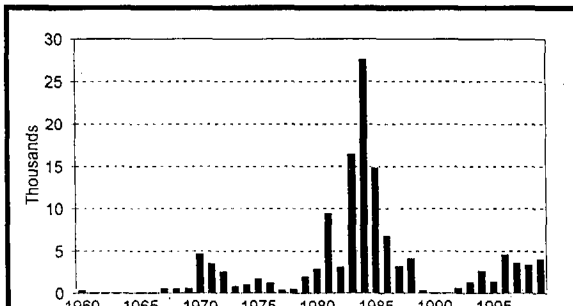
A revised flow schedule for the lower Merced River was formulated by DFG (1993) based on instream flow study and smolt survival data from similar drainages. DFG concluded that, although the recommended flows are a significant improvement over the presently required releases, they are not optimal for salmon spawning, rearing, or emigration, particularly in drier years. USFWS (1995) recommended flows that would contribute to its Central Valley Project Improvement Act (CVPIA) goal of doubling anadromous fish production in the basin, but did not include any measures to recover steelhead. The most significant deficiencies for steelhead are unsuitable water temperatures for summer rearing.

Poor water quality delays spawning, decreases egg survival, and causes high juvenile mortality. Stream temperature on the river often exceeds temperature tolerances for salmon spawning and egg incubation in October and early November in at least a portion of the spawning reach. High water temperature delays upstream migration and spawning. In recent drought years, salmon have not spawned in the river until after the first week of November, when water temperature has dropped to tolerable levels._

In late April and May, stream temperature often exceeds stressful levels for emigrating smolts. Elevated spring temperatures are a more significant problem in the lower Merced River than in the other San Joaquin tributaries because of higher ambient air temperatures and lower flows.

Crocker-Huffman Dam, near the town of Snelling, is the upstream barrier for salmon and steelhead migration. Salmon spawn in the 24-mile reach between Crocker-Huffman Dam and the Town of Cressey. Rearing habitat extends downstream of the designated spawning reach to the mouth.

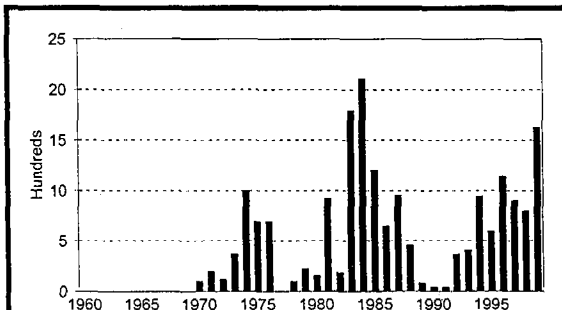
Historically, the river supported spring- and fall-run chinook salmon and steelhead. Historical information and the presence of spring-run chinook salmon provide ample evidence that a steelhead run was present historically in the Merced River (Yoshiyama et al. 1996; CDFG 1997), and there is some evidence that they were able to migrate as far upstream as Yosemite Valley (Hubbs and Wallis 1948; Snyder 1993). The river now supports fall-run chinook salmon and perhaps steelhead and late-fall-run chinook salmon.



Fall-run Chinook Salmon Returns to the Merced River excluding returns to Merced River Hatchery, 1960-1999 (CDFG 1999).

As with the Stanislaus and Tuolumne Rivers, the number of late-fall-run chinook salmon and steelhead in the Merced River is unknown. Each year, a few large rainbow trout, possibly steelhead, enter the Merced River Hatchery (MRH). Also, an adult steelhead was captured immediately above the Hills Ferry Salmon Barrier just upstream of the Merced River confluence in November, 1996 (Mayott 1997). Because there has been no focused effort to assess the steelhead population in the Merced River, and there is essentially no indirect or bycatch information from other monitoring programs on which to estimate a probability of extinction, there is no information available to conclude that steelhead are extirpated from the Merced River. This fact, and the anecdotal information and observations cited above, have led CDFG to conclude that a remnant steelhead population still exists in the Merced River (CDFG 1997).

As with other tributaries in the basin, fall-run chinook salmon spawning escapements in the lower Merced River have varied significantly since surveys were initiated. Construction and operation of MRH, in combination with increases in instream flows related to the 1967 Davis-Grunsky Contract, have increased the Merced River salmon run. Before 1970, spawning escapements were generally less than 500 fish annually; since that time, annual runs have averaged 5,800 fish. During the 1987 through 1992 droughts, spawning escapements in the lower Merced River declined to seriously low levels. In fall 1991, fewer than 100 fish returned to spawn, compared to a recent high of 23,000 fish in 1985. Extremely low returns to MRH in late 1980s and early 1990s



Fall-run Chinook Salmon Returns to Merced River Hatchery, 1970-1999 (CDFG 1999).

severely limited the hatchery's ability to sustain San Joaquin basin salmon through droughts.

MRH, located below Crocker-Huffman Dam, is presently the only salmon hatchery in the San Joaquin River drainage south of the Delta. Operated by the DFG, MRH was constructed in 1970 and operated for 10 years with funding provided in the Davis-Grunsky Agreement. The hatchery has been valuable in augmenting and sustaining salmon runs in the lower Merced River and in the Stanislaus and Tuolumne Rivers and providing fish for study purposes throughout the San Joaquin basin. The facility was recently modernized using funding from the Salmon Stamp Program and the DWR Four Pumps Agreement.

Merced NWR is located in the southern portion of this Ecological Management Zone. The refuge encompasses 2,561 acres and provides about 700 acres of seasonally flooded marsh and 600 acres of corn, alfalfa, irrigated pasture, and winter habitat. The marshes are flooded from October through April and attract thousands of migrating and wintering birds, especially ducks, geese, cranes, and shorebirds. The agricultural land provides forage for lesser sandhill cranes and four species of geese.

Preliminary surveys on the Merced River indicate that the major needs for salmon habitat improvement include rehabilitating riffle areas, constructing or repairing levees and channels to isolate mining pit areas from the active stream channel, and modifying diversion structures. The existing abandoned gravel pits also serve as predator habitat and trap sediments transported from upstream areas.

Steelhead recovery options for the Merced River have not been addressed by the management agencies. However, the ESA listing of steelhead populations in the San Joaquin tributaries will necessitate that options be identified and implemented. As with other regulated rivers in the Central Valley, recovery measures will need to focus on providing access to historical habitats and/or maintaining adequate water temperatures below dams for oversummer rearing of juveniles. These issues will need to be addressed in future recovery planning.

Illegal harvest of upstream-migrating adult salmon has also been identified as a factor limiting salmon production in the Merced River. Low water flows during the fall salmon migration make salmon easy prey for poachers.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the East San Joaquin Basin Ecological Management Zone includes improved streamflow, greater sediment supplies, lower spring through fall stream temperatures, improved upper watershed health, improved foodweb productivity, and improved habitats, including riparian, wetland, and seasonally flooded aquatic habitats. In addition, actions to reduce stressors, such as screening unscreened diversions, reducing the effects of gravel mining, reducing wild salmon and steelhead harvest, and limiting the adverse effects of introducing hatchery fish, will help restore salmon and steelhead populations in zone rivers.

The vision focuses on restoring important fish, wildlife, and plan communities and their habitats by restoring ecological processes and reducing stressors. Primary focus will be on restoring or reactivating the ecological processes that create and maintain habitats for anadromous salmonids and riparian vegetation. In each of the zone rivers, focus will be on restoring and protecting a self-sustaining stream meander corridor and an associated diverse riparian community that provide shade, nutrients, and woody debris to the rivers, as well as habitat for plants and wildlife communities. Because dams on each of the rivers interrupt the natural sediment supply on which natural stream meander depends, it will be necessary to sustain some natural sediment supply artificially, including silt, sand, and gravel.

In addition to restoring a natural stream channel process, it will also be necessary to restore natural floodplain processes needed to enhance foodweb productivity. These processes provide habitat for juvenile salmon and steelhead and spawning habitat for splittail and other native resident (non-migratory) fish, and habitat for migratory waterfowl and shorebirds. Natural floodplain processes occur in areas that receive seasonal flooding overflows adjacent to the stream channel, such as riparian forests, oxbows, and seasonal wetlands. These habitats depend on seasonal flooding, and the rivers and Delta depend on floodplain recruitment. Gravel is needed to maintain stream channel configuration (structure) and spawning habitat for salmon and steelhead.

Throughout the basin, restoring and/or protecting a self-sustaining, diverse riparian community will be emphasized to maintain nutrient and woody debris input to the aquatic system, enhance bank stability and stream shading, and provide valuable habitat for a variety of species.

In the lower Stanislaus, Tuolumne, and Merced rivers, emphasis will be on restoring fall-run chinook salmon and steelhead populations. Because spawning and rearing habitats are degraded, and poor streamflows and stressors have depressed the populations, it may be necessary to continue or expand hatchery rearing of salmon and steelhead, at least in the short term, to maintain sufficient production in these rivers to support sport and commercial fisheries. However, hatcheries will be operated to preserve the genetic identity of endemic (native to a particular locality), naturally spawning stocks of chinook salmon and steelhead trout. Hatchery-produced fish will be used to support sustainable ocean recreational and commercial fisheries and directed fisheries in the rivers. Marking techniques will enable sport and commercial anglers to distinguish between hatchery-produced and naturally produced fish to minimize wild fish harvest.

The Ecosystem Restoration Program (ERP) envisions that the fish, wildlife, and riparian needs of the East San Joaquin Basin Ecological Management Zone will be met and acceptable ecosystem health will be achieved when the following visions have been satisfactorily attained.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

STANISLAUS RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Stanislaus River Ecological Management Unit is to improve natural fall-run chinook salmon and steelhead populations by providing suitable water temperatures for rearing juveniles and improving spring flows below New Melones Dam in dry and normal water years, summer through winter base flows, and spawning and rearing habitat.

The vision for the Stanislaus River Ecological Management Unit includes improving streamflow, gravel recruitment, stream channel and riparian habitat, and screening diversions to increase the survival of chinook salmon, steelhead, and native resident fish and wildlife. Managing flow releases to provide suitable habitat and water temperatures for key resources is critical to ecosystem restoration. Also important will be restoring natural channel configurations and gravel recruitment, transport, and cleansing processes. Improved land use and livestock grazing practices will contribute to improved riparian habitat. Reducing non-native fish populations, entrainment of aquatic resources at water diversions, contaminant input, and illegal harvest will further benefit salmon and steelhead. Restoring a diverse, self-sustaining riparian corridor linked with upstream and downstream areas will be critical in restoring ecosystem function.

Restoring fall-run chinook salmon in the Stanislaus River could have significant benefits to sport and commercial fisheries. Historically, spawning escapements of fall-run chinook in the Stanislaus River have numbered up to 7% of the total fall-run salmon escapement in the Central Valley. The restoration program has the potential to return populations to recent historic levels, which could improve coastal sport and commercial fisheries.

The vision for the Stanislaus River includes reactivating and maintaining important ecological processes that create and sustain habitats for salmon and steelhead. Streamflow should be enhanced below Goodwin Dam by providing base flows recommended by the AFRP and a spring flow event in late April or early May in normal and wet years, and suitable temperatures for juvenile steelhead rearing in summer. Higher, more natural spring flow events will assist young salmon and steelhead on their downstream migration to the Bay-Delta and ocean and also support natural stream channel and riparian habitat restoration. Pulse flows also benefit the river and Bay-Delta foodweb production. The added flows in the Stanislaus River, in combination with similar flow events from the Tuolumne and Merced Rivers, will assist young salmon from all three rivers on their downstream journey through the lower San Joaquin River, Delta, and Bay to the ocean. An improved stream meander corridor and associated SRA habitat, in combination with improved gravel recruitment and water temperatures, will provide more suitable habitat for salmon and steelhead spawning and rearing, which should lead to greater natural salmon and steelhead production in the Stanislaus River. Improvements in the upper watershed health from reduced forest fuel levels and less risk of catastrophic wild fires, along with less erosion from improved road construction and maintenance, will help protect water supply and water quality.

Stream channel and riparian habitat will be improved by increasing streamflow, protecting the natural gravel sources, reducing erosional areas that degrade spawning habitat, and promoting the conservation of the lower river active floodplain. Islands will be protected and restored where possible. Side channels will be restored, and riparian vegetation and SRA habitat and woody debris will be developed to enhance juvenile salmon and steelhead habitat. Planting vegetation or regrading the disturbed channel and floodplain may be required in certain areas to hasten and sustain recovery.

Stressors, including unscreened or poorly screened diversions and illegal and legal harvest, will be evaluated to determine whether actions are necessary to protect salmon and steelhead populations. Measures being considered to reduce harvest of naturally spawning chinook salmon in sport and commercial fisheries include establishing harvest restrictions and marking all hatchery-produced fish, which would allow a selective harvest of hatchery fish. Enforcement would be increased to reduce poaching.

TUOLUMNE RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Tuolumne River Ecological Management Unit includes maintaining suitable water temperatures, restoring streamflow, gravel recruitment, and stream channel and riparian habitat to improve habitat for chinook salmon, steelhead, native resident fish, native amphibians and reptiles, and wildlife. The vision also includes restoring important ecological processes that will improve habitat for fall-run chinook salmon, late-fall-run chinook salmon, steelhead, riparian vegetation, and wildlife resources. Managing flow releases to maintain suitable habitat and water temperatures for salmon and steelhead will be essential for restoring the ecosystem. Flow improvements in the revised agreement and FERC license should be implemented and monitored for effectiveness. Streamflow management for the Tuolumne River will need to be integrated with flow management on the other San Joaquin tributaries and the lower San Joaquin River to obtain the greatest benefits.

Also, important will be restoring more natural channel configurations; restoring gravel recruitment, transport, and cleansing processes; and restoring a balanced fine sediment budget. This will be accomplished by implementing improved land use and livestock grazing practices, reducing non-native fish populations and habitats that support them, reducing young salmon losses at water diversions, reducing the input of contaminants, and reducing the illegal salmon harvest. Restoring a diverse, self-sustaining riparian and stream channel corridor linked with upstream and downstream areas will be an essential element in the ecosystem restoration plan.

Restoring fall-run chinook salmon in the lower Tuolumne River could have significant benefits. Historically, spawning escapements in the river have numbered up to 12% of the total fall-run salmon escapement in the Central Valley. Implementing the restoration program has the potential to restore the population to recent historic levels, which will also benefit sport and commercial fisheries along the coast of California.

Streamflows should be enhanced below Don Pedro Dam by providing base flows recommended by DFG. In addition to the DFG recommendation, a spring flow event in late April or early May in dry, normal, and wet years would be provided to support downstream emigration of juvenile salmon and steelhead and to benefit stream channel and riparian habitat. Also, adequate cold water releases from Don Pedro Dam should be made to maintain suitable water temperatures in summer and early fall for juvenile steelhead rearing.

Existing gravel recruitment sources will be protected and supplemented where and when necessary with gravel introductions. A cooperative program among the local counties, agencies, and the aggregate resource industry will be developed to improve or relocate gravel mining from the active stream channel.

Stream channel and riparian habitat will be improved by increasing streamflow, protecting natural gravel sources, reducing erosional areas that degrade spawning habitat, and promoting the conservation of the lower river active floodplain. Islands will be protected and restored where possible. Side channels will be restored, and riparian vegetation and SRA habitat and woody debris will be developed to enhance juvenile salmon and steelhead habitat. Vegetation planting or regrading of the disturbed channel and floodplain may be required in certain areas to hasten and sustain recovery.

Stressors will be addressed. A cooperative evaluation of unscreened and inadequately screened diversions will determine the feasibility of installing positive-barrier fish screens. Measures being considered to reduce naturally spawning chinook salmon harvest in sport and commercial fisheries include establishing harvest restrictions and marking all hatchery-produced fish, which would allow a selective harvest of hatchery fish. A selective fishery on hatchery-produced fish will reduce harvest of naturally produced Tuolumne chinook salmon. Enforcement would be increased to reduce poaching.

If future baseline chinook salmon populations do not respond favorably to improved flow and habitat conditions in the Tuolumne River, San Joaquin River, and the Delta, a comprehensive evaluation will be made of the need for additional artificial propagation of chinook salmon in the basin. This evaluation would consider direct and indirect effects on the wild population, the role of hatchery fish in maintaining naturally spawning and hatchery derived salmon, disease transmission between hatchery and natural stocks, genetic structure and diversity of all stocks in the basin, and the likelihood of maintaining existing genetic diversity of the Tuolumne stock. Efforts relating to artificial propagation of salmon and steelhead will be the subject of monitoring, focused research, and adaptive management.

TUOLUMNE RIVER WATERSHED DEMONSTRATION PROJECT: The Tuolumne River watershed has tentatively been selected as a demonstration watershed for the CALFED Stage 1 (first seven years) Implementation Program. During Stage 1 CALFED will support ongoing and enhanced management and restoration efforts in the watershed. Success in Stage 1 will set the stage for subsequent implementation phases as the restoration and management information gained from the effort in the Tuolumne watershed will have broad application in designing and implementing similar programs in similar watersheds in the San Joaquin Basin and elsewhere in the Central Valley.

Although the ecological integrity of the Tuolumne River has declined, considerable opportunities exist to improve the river corridor through rehabilitating important ecological processes. The following descriptions of attributes of alluvial river ecosystem integrity are cited directly from McBain and Trush (1998). These not only form a basis for the Tuolumne River restoration vision but also provide a basis for selecting actions for CALFED Stage 1 Implementation.

SPATIALLY COMPLEX CHANNEL MORPHOLOGY: No single segment of channel bed provides habitat for all species, but the sum of channel segments provides high-quality habitat for native species. A wide range of structurally complex physical environments supports diverse and productive biological communities.

FLOWS AND WATER QUALITY ARE PREDICTABLE VARIABLE: Inter-annual and seasonal flow regimes are broadly predictable, but specific flow magnitudes, timing, durations and frequencies are unpredictable due to runoff patterns produced by storms and droughts. Seasonal water quality characteristics, especially water temperature, turbidity, and suspended sediment concentration are similar to regional unregulated rivers and fluctuate seasonally. This temporal "predictable unpredictability" is a foundation of river ecosystem integrity.

FREQUENTLY MOBILIZED CHANNELBED SURFACE: In gravel-bedded reaches, channelbed framework particles of coarse alluvial surfaces are mobilized by the bankfull discharge, which on average occurs every 1-2 years. In sand-bedded reaches, bed particles are in transport much of the year, creating migrating channebed "dunes" and shifting sand bars.

PERIODIC MOBILIZED CHANNELBED SCOUR AND FILL: Alternate bars are scoured deeper than their coarse surface layers by floods exceeding 3-to-5 year annual maximum flood recurrences. This scour is typically accompanied by redeposition, such that net change in channelbed topography following a scouring flood usually is minimal. In gravel-bedded reaches, scour was most likely common in reaches where high flows were confined by valley walls.

BALANCED FINE AND COARSE SEDIMENT BUDGETS: river reaches export fine and coarse sediment at rates approximately equal to sediment inputs. The amount and mode of sediment storage within a given river reach fluctuates, but sustains channel morphology in dynamic quasi-equilibrium when averaged over many years. A balanced coarse sediment budget implies bedload continuity; most particle sizes of the channelbed must be transported through the river reach.

PERIODIC CHANNEL MIGRATION AND/OR AVULSION: The channel migrates a variable rates and establishes meander wavelengths consistent with regional rivers with similar flow regimes, valley slopes, confinement, sediment supply, and sediment caliber. In gravel-bedded reaches, channel relocation can also occur by avulsion, where the cannel moves from one location to another, leaving much of the abandoned channel morphology intact. In sand-bedded reaches, meanders decrease their radius of curvature over time, and are eventually bisected, leaving oxbows.

A FUNCTIONAL FLOODPLAIN: On average, floodplains are inundated once annually by high flows equaling or exceeding bankfull stage. Lower terraces are inundated by less frequent floods, with their expected inundation frequencies dependent on norms exhibited by similar, but unregulated river channels. These floods also deposit finer sediment onto the floodplain and low terraces.

INFREQUENT CHANNEL RESETTING FLOODS: Single large floods (e.g., exceeding 10-to-20 years recurrences) cause channel avulsions, rejuvenate mature riparian stands to early-successional stages, form and maintain side channels, and create off-channel wetlands (e.g., oxbows). Resetting floods are as critical for creating and maintaining channel complexity as lesser magnitude floods, but occur less frequently.

SELF-SUSTAINING DIVERSE RIPARIAN PLANT COMMUNITIES: Based on species life history strategies and inundation patterns, initiation and mortality of natural woody riparian plants culminate in early- and late-successional stand structures and species diversities (canopy and understory) characteristic of self-sustaining riparian communities common to regional unregulated river corridors.

NATURALLY-FLUCTUATING GROUNDWATER TABLE: Inter-annual and seasonal groundwater fluctuation patterns in floodplains, terraces, sloughs, and adjacent wetlands are similar to regional unregulated river corridors.

In summary, the types of actions that should be further examined to promote restoration of the Tuolumne River corridor include:

- Encourage inter-annual and seasonal flow variability,
- Increase the magnitude and frequency of short duration peak flows to initiate bed mobility and localized scour and deposition,
- Increase the magnitude and frequency of peak flows to initiate bed scour on alluvial deposits along the low water margin to reduce riparian encroachment,
- Increase coarse sediment input to balance mainstem transport capacity,
- Reduce fine sediment input to the river,
- Reduce human encroachment onto floodplains to allow limited channel migration, and
- Restore channel morphology, with a bankfull channel and floodway scaled to the expected high flow regime.

Cumulatively, an investment in the Tuolumne River watershed during Stage 1 will provide direct benefits to the creek and dependent fish and wildlife resources and provide the types of information required to move the Ecosystem Restoration Program into subsequent implementation phases successfully. A few of the lessons to be learned in the Tuolumne River watershed include methods to improve overall watershed and ecosystem health; how to integrate local, state, federal and private efforts in a large-scale restoration program; how to design and implement actions to benefit anadromous and resident fish species, riparian systems and riparian-dependent mammals and birds; and how to best implement actions below dams in a highly altered hydrologic system to restore function sediment transport and other important ecological processes.

MERCED RIVER ECOLOGICAL MANAGEMENT UNIT

The vision for the Merced River Ecological Management Unit includes maintaining suitable water temperatures, restoring streamflow, coarse sediment recruitment, and stream channel and riparian habitat to improve habitat for fall-run chinook salmon, late-fall-run chinook salmon, steelhead, riparian vegetation, and wildlife resources. The vision also includes restoring the important ecological functions and processes that will improve habitat for fall-run chinook salmon, late-fall-run chinook salmon, steelhead, native amphibians and reptiles, riparian vegetation, and wildlife resources. Managing flow releases to provide suitable habitat and water temperatures for these resources will be essential to restoring the ecosystem. Streamflow management for the Merced River will need to be integrated with flow management on the other San Joaquin tributaries and the lower San Joaquin River to obtain the greatest possible benefits, because the salmon and steelhead must also pass through the lower San Joaquin River and Bay-Delta on their way to and from the Pacific Ocean.

Also important will be:

- restoring more natural channel configurations; restoring gravel recruitment, transport, and cleansing processes,
- restoring a balanced fine sediment budget by implementing improved land use and livestock grazing practices,
- reducing non-native fish habitat,
- reducing the loss of young salmon at water diversions,
- reducing the input of contaminants,
- reducing the number of adult fish straying into areas with no suitable spawning habitat,
- and reducing illegal salmon harvest.

Restoring a diverse, self-sustaining riparian corridor linked with upstream and downstream areas will be critical to restoring ecological health to the Merced River watershed. MID plays an important role in restoration efforts on the lower Merced River. The district is working in cooperation with resource agencies on research and restoration projects for fall-run chinook salmon in the basin.

Streamflow should be enhanced below Lake McClure by providing minimum flows recommended by DFG. In addition to the DFG recommendation, a spring flow event would be provided in dry, normal, and wet years. The pulse flow would emulate a natural pulse flow that would normally occur if flows were unimpaired. A spring flow event will support juvenile salmon and steelhead emigrating to the Delta, Bay, and ocean. It would also support natural stream channel and riparian habitat development. Also, adequate cold water releases from Lake McClure should be made to maintain suitable water temperatures in summer and early fall for juvenile steelhead rearing.

Existing gravel sources will be protected and the natural gravel supply supplemented where and when necessary. A cooperative effort among local counties, agencies, and the aggregate resource industry will be encouraged to evaluate relocating gravel mining to areas outside of the active stream channel.

Stream channel and riparian habitat will be improved by increasing streamflow, protecting the natural gravel sources, reducing erosional areas that degrade spawning habitat, and promoting the conservation of the lower river active floodplain. Islands will be protected and restored where possible. Side channels will be restored, and riparian vegetation and SRA habitat and woody debris will be developed to enhance juvenile salmon and steelhead habitat. Vegetation planting or regrading of the disturbed channel and floodplain may be required in certain areas to hasten and sustain recovery. Large mined-out gravel pits in the stream channel will be isolated or restored to natural conditions.

The effects of stressors, including artificial propagation of salmon and steelhead, water diversions, and illegal and legal harvest, will be assessed and reduced, if necessary. Stocking fall chinook salmon reared in the MRH requires careful consideration of the effects to naturally spawning stocks, not only in the Merced River, but in adjacent Central Valley watersheds. Choice of genetic types of adult salmon selected for the hatchery will be carefully evaluated to minimize potentially damaging effects on the genetic integrity of wild populations in the Central Valley. A cooperative evaluation will be made of the need and feasibility of installing positive-barrier fish screens on diversions. Measures being considered to reduce wild chinook salmon harvest in sport and commercial fisheries include establishing harvest restrictions and marking all hatchery-produced fish, which would allow a selective harvest of hatchery fish. Enforcement would be increased to reduce poaching.

Restoring and maintaining the Merced River could be facilitated by developing and implementing a comprehensive watershed management plan to protect the channel (e.g., maintain flood control capacity and reduce bank erosion) and preserve and restore the riparian corridor.

VISIONS FOR ECOLOGICAL PROCESSES

Important ecological processes and functions in the East San Joaquin Basin Ecological Management Zone include the annual streamflow regime (pattern), coarse sediment supply, stream meander, natural stream channel configurations, and water temperature regime. These processes are in various states of health in the zone. The greatest need is to restore the functions and processes linked to streamflow.

CENTRAL VALLEY STREAMFLOWS: Streamflow shapes stream channels and riparian vegetation; provides fish habitat; keeps water temperature lower in rivers; attracts anadromous fish to spawning streams; and transports young anadromous fish to downstream nursery areas in the San Joaquin River, Bay-Delta estuary, and ocean. Streamflow in each of these rivers is impaired by upstream storage reservoirs and diversions, particularly in dry and normal rainfall years. A healthy streamflow pattern in the rivers would emulate the natural runoff pattern, with a spring flow event and summer-fall-winter base flows that maintain important ecological processes and functions, habitats, and important species. The vision for streamflows is to provide a short-term (10-day) flow event in spring that typically occurred at least once in dry and normal years before dams and reservoirs were built. In addition, base flows would be provided during the remainder of the year to sustain habitats and species.

COARSE SEDIMENT SUPPLY: Gravel recruitment into the rivers is important in providing a natural stream meander process, channel configuration, and stream substrate (bottom materials where plants and animals thrive), as well as essential spawning gravels for salmon and steelhead. A natural sediment supply is also important for restoring riparian and wetland habitat. Sediment transport and gravel recruitment have been greatly reduced below major dams in zone rivers. Not only has sediment from the upper watersheds been eliminated, but sediment from the lower rivers has been interrupted by bank protection, levees, and gravel mining. The vision is to supplement natural gravel below major dams on the three rivers, where needed for salmon and steelhead spawning habitat, riparian habitat, and natural stream channel and meander development. In addition, where bank protection, levees, and gravel mining have hindered natural sediment supply to the river, wherever possible, local sediment supplies will be made available to the river.

STREAM MEANDER: In their floodplains, Central Valley rivers naturally meander through floodplain sediments, progressively eroding the next bank while adding to the previous bank. This stream meander process occurred in the stream corridors of the Stanislaus, Tuolumne, and Merced rivers. A limited stream-meander process in the lower floodplain of the rivers would provide much needed habitat to support healthy riparian systems, wildlife, and aquatic species. Today, the natural meander process in each of the streams is inhibited by dams, altered stream flows, bank protection, bridge abutments, and flood control levees. In some places, bank erosion occurs, but lack of sediment stops forming of the previous banks. The vision is to restore a portion of the natural meander to the rivers by setting back levees, where possible, and removing structures that inhibit the process from the meander corridor.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: The San Joaquin Valley formerly had many natural overflow basins that retained floodwaters, permitted sediment deposition, and provided fish and waterfowl habitat. Partially reactivating these important ecological functions will contribute to overall system health and provide for prolonged periods of natural streamflow and sediment input. Natural overflow basins would also supply important habitat for fish, including chinook salmon and splittail, as well as foraging habitat for many waterfowl. The vision is to restore natural overflow basins within the lower floodplains of the three rivers. This would provide additional flood control protection for other areas in this zone and downstream, as well as valuable natural wetland, riparian, and aquatic habitats for fish and wildlife.

CENTRAL VALLEY STREAM TEMPERATURES: Salmon and steelhead depend on cool